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Magnetization of Fe Doped Semimagnetic Semiconductors

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Semimagnetic semiconductors usually consist of a compound semiconductor in which the cation has been replaced by an ion from the 3d transition elements. Especially the II-VI compounds ZnS, CdS, HgS, ZnSe, CdSe, HgSe, ZnTe, CdTe, and HgTe in which Zn, Cd, or Hg have been replaced by Mn have been studied extensively. It was found that in the magnetization steps occur due to the crossing of the lowest energy level of Mn-Mn nearest neighbour pairs whose spins are coupled antiferromagnetically.

Recently Fe and Co ions are put into the II-VI compounds. The magnetic properties of these materials are somewhat more complicated, because, unlike Mn^{2+} , Fe^{2+} and Co^{2+} have an orbital moment, so that their energy levels are affected by the crystal field. Therefore their magnetic properties can only be calculated numerically. For Fe in ZnSe, this calculation has been done using the spectroscopic splitting factor $\Delta=4116$ K and the spin-orbit interaction $\lambda=133$ K. The antiferromagnetic exchange constant between two nearest neighbour Fe^{2+} spins is estimated from high temperature susceptibility measurements to be $J = -22$ K. In this case the dependence of the energy levels of a pair of Fe^{2+} ions on the magnetic field is like in Fig. 1 and the resulting magnetization is given in Fig. 2. When the interaction $|J|$ is below a critical value of about 15 K, no crossing of the lowest energy level and no steps in the magnetization will occur. Until so far no steps have been observed, but these would be valuable for an accurate determination of the antiferromagnetic exchange constant J in these materials.

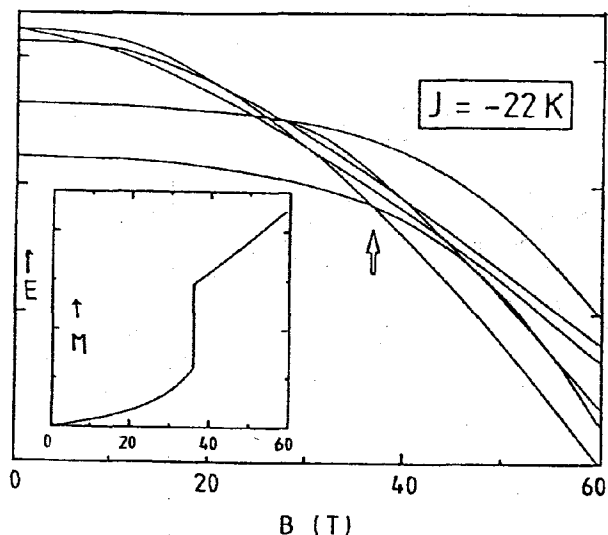


Fig. 1. The magnetic field dependence of the energy levels of a pair of Fe^{2+} ions in ZnSe. Note the crossing of the lowest level around 36 T.

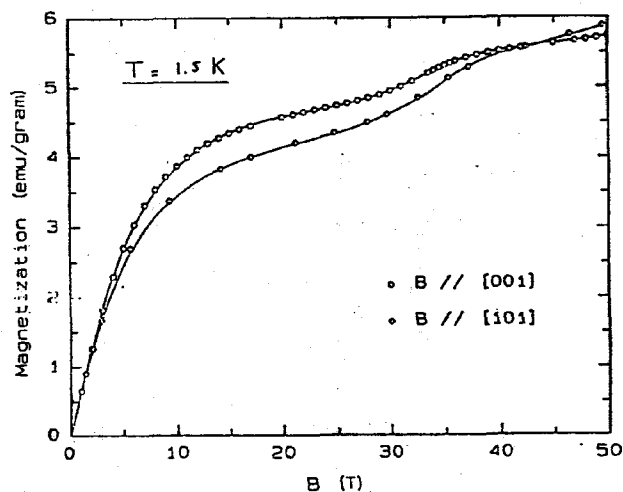


Fig. 2. The magnetization of $\text{Zn}_{0.95}\text{Fe}_{0.05}\text{Se}$ as function of the magnetic field at 1.5 K along two crystallographic directions.